650.1900 Introduction

The tools contained in NEH Chapter 19 have been reviewed for use in Minnesota. The applicable situations for use of each tool are described in this Minnesota supplement to Part 650 Engineering Field Handbook (EFH) Chapter 19.

650.1901 Use of stream and lake gages

A computer program for applying this tool is available through the engineers in the Minnesota state office of NRCS. However, few rivers in Minnesota have the type of floodplain where this tool will be helpful. Analysis has been completed for parts of the Minnesota River, especially in and around Nicollet County and may be obtained from the state office. Contact the State Conservation Engineer for further information and/or assistance.

650.1902 Runoff volumes

At this time, no data analysis has been done in Minnesota for applying this tool. The analysis would be lengthy to provide meaningful information; no plans exist at this time to use this tool in Minnesota.

650.1903 Supplemental data for remote sensing

This tool is extensively used in Minnesota in conjunction with the Minnesota mapping conventions. For the years that the slides are available in a given county, monthly rainfall amounts during the growing season are entered into a spreadsheet format for use with the procedure described in part 650.1903. All the slides are examined for possible wet signatures. The slides of "normal" years, as determined by the evaluation procedure described in 650.1903, are examined and the number of normal years with wet signatures is determined as a percentage of the total number of normal years. National Oceanic and Atmospheric Administration (NOAA) weather stations are used since information is available for those sites on the internet (www.wcc.nrcs.usda.gov) and they have a long term record where normals and temperature information are also available. An individual evaluation may use a local cooperating rainfall gage operator's record, and compare it to the NOAA record if circumstances indicate that the meteorological distribution of rainfall would not accurately be captured by the NOAA station's record. This should be considered supplemental, and the NOAA station information should be included in the case file.

Further information on this procedure with an example is given in the student notebook for the National Employee Development Center (NEDC) course "Hydrology Tools for Wetland Determination".

650.1904 DRAINMOD

Contact the State Conservation Engineer for assistance with DRAINMOD.

650.1905 Scope and Effect Equations

(a) Encirclement

Every site evaluated should be considered for possible encirclement, or cutting off the water supply to a wetland that keeps it wet. Encirclement is accomplished by interrupting the flow of surface or subsurface water that is significant to the water budget of the wetland. A tile line or ditch can act as an underground diversion, or surface intakes or a ditch can intercept surface water and keep it from reaching the wetland. A tile placed adjacent to a wetland across the portion of the landscape that allows groundwater to reach the wetland to keep it wet is acting as an underground diversion. This often has enough impact to remove or noticeably impact a wetland. In cases where a subsurface drainage system may act as an underground diversion, the distance to keep drainage systems back from a wetland is three times the usual lateral effect distance in the direction(s) where the groundwater is expected to travel toward the wetland. This is to minimize the impact of the drain on the groundwater especially which tries to reach the site but surface water may be a consideration also.

(b) Instructions for using the DRAIN computer program to calculate lateral effect

The DRAIN computer program was developed by Terry Carlson, Assistant State Conservation Engineer (retired) in Bismarck, North Dakota, with assistance from Sonia Maassel Jacobsen, Hydraulic Engineer in St. Paul, Minnesota; Roy Boschee, Wetland Team Hydrologist in Rapid City, South Dakota; and Laurel Foreman, Hydraulic Engineer in Des Moines, Iowa. The original version was dated May 14, 1998. The current version is dated February 28, 2003 and was developed to work with the soils data from the NASIS database. Within the program the version date is shown as 08/02.

This program will calculate lateral effect using four different methods: 1) ellipse, 2) Hooghoudt, 3) van Schilfgaarde and 4) Skaggs' drain in a semi-infinite medium. The help screens associated with the program explain a little more about each of the four methods. The program is to be used with files of soils information and drainable porosities. Layer thicknesses of a given soil may vary from county to county. Lateral effect is determined in the soil in which the drainage system is installed.

Three different scenarios may require use of lateral effect computations. Note the three situations in Figures 1, 2, and 3 in Exhibit 1. In the instructions which follow, some differences are given for input parameters depending on the circumstances involved. For computing distances to stay away from wetlands with new tile (Figure 3), a variable time factor is used. This variable accounts for climatic differences that can affect the lateral effect distance. For instance, South Dakota will have larger setbacks than southeastern Minnesota due to the drier climate and less chance of replenishing rainfall. See Exhibit 2 for the map of the time factors to use in the van Schilfgaarde equation. County specific tables have been developed for commonly used soils in many counties. For other soils, the computer program can be used.

<u>Instructions:</u>

1. The van Schilfgaarde equation is to be used in Minnesota in MLRA 102 (adjacent to South Dakota) as agreed to by hydrologists from the states of North Dakota, South Dakota, Minnesota and Iowa in 1998. The van Schilfgaarde equation is meant for pattern drainage situations and for sites where the drain passes through a wetland and affects its hydrology. The Skaggs equation is to be used outside MLRA 102 when a drain is being installed near a wetland but not through it. The ellipse and Hooghoudt equations are simplifications which are not recommended for general use.

2. If a soil is not listed in the computer program's database, use the lateral effect distances calculated for a similar soil. This should be done in consultation with a soil scientist as the drainage features of a soil are what make it similar for this application, not texture alone.

3. If variations in soil properties cause wide variations in lateral effects for a given soil from county to county, work with the soil scientists in the area to determine what is appropriate for that soil. Wide variations should not occur on either state or county lines.

4. Use the number of days as whole integers in the van Schilfgaarde equation.

5. Round all values of lateral effect within reason to the nearest 5 or 10 feet. The lateral effect distances may be rounded to provide more uniform values of lateral effect. For example, one Glencoe soil at a 4' depth produces Le=101 feet for T=12 days and Le = 105 feet for T=13 days. Both of these values could be rounded to 105 feet and thus would appear as the same value in two counties that may require use of a different number of days.

Input parameters for the van Schilfgaarde Equation:

Drainable Porosity, voids at 60 cm tension: This parameter is used to describe the fraction of the soil volume that is water that can be removed by a subsurface drain. This is expressed as a dimensionless value. When the soil is chosen from the input list using the Soil Data pull-down menu, the drainable porosity is entered by the program. The DRAIN-NASIS program uses soils files that include the drainable porosity values which were calculated by the Rosetta pedotransfer function and the van Genuchten equation.

Hydraulic Conductivity, K (above and below the drain in inches per hour): When the soil is chosen from the list offered by the Soil Data pull-down menu, the hydraulic conductivity – as calculated by the Rosetta pedotransfer function – is automatically entered into the calculations. For each site, soils information is obtained from field investigations and published soil surveys. The DRAIN-NASIS program uses soils data for a specific county. The soils vary, especially in layer thickness, from one county to another. The permeabilities are given as a range for each soil, and the Rosetta pedotransfer routine uses an average of the range given. Below the lowest depth given in the soils data, the drainage class is lowered by one to account for compaction from the soil above, less root channels, less weathering, and reduced earthworm activity. Again, an average value for the range given in the soils database is used. This will have units of inches per hour in the soils database but is converted to feet per day for use with computations. DRAIN-NASIS makes this conversion.

Initial Water Level Height Over Barrier (ft): This is also known as the depth to the impermeable layer. This depth is needed to identify a “bottom” to the calculations, that is, a point where the flow lines are turned horizontally and do not continue vertically. A soil layer that has a permeability of 1/10th or less of the soil layer above it can be considered relatively impermeable for this purpose. Use a depth of 10 feet if the impermeable layer has not been encountered above that point. At this point the compaction of the soil due to the weight of 10 feet of soil above it is reducing the permeability sufficiently to justify this depth. If the impermeable layer occurs above 10 feet, use that depth. Use units of feet. The soil is assumed to be saturated to the surface when time is zero.

Final Water Level Height over Barrier (ft): After a period of time has elapsed, such as 14 days for the situations in Figures 1 and 2, the water table is assumed to be at a known point below the ground surface. By the hydrology criteria in the National Food Security Act Manual (NFSAM) for Figures 1 and 2, and by agreement for the situation in Figure 3, this is 1 foot for non-sandy soils. Thus the value entered in this line is the depth to the impermeable layer minus the one foot. In sandy soils in the situations described in Figures 1 and 2, this value is only 0.5 foot. Note that these water table depths, 6” or 12”, are as described in the NFSAM for hydrology, not soils.

Table 1. Permeability Classes and Average Rate used by DRAIN Computer Program

Permeability, inches/hour	Class Name	Average Rate, inches/hour
< 0.06	Very slow	0.03
0.06 - 0.2	Slow	0.13
0.2 - 0.6	Moderately slow	0.4
0.6 - 2.0	Moderate	1.3
2.0 - 6.0	Moderately rapid	4.0
6.0 - 20.0	Rapid	13.0
> 20.0	Very rapid	20.0

Drain Height above the Barrier (ft): Measuring from the point chosen as the impermeable layer, determine the distance from the impermeable layer to the bottom of the drain. This will often be 10 feet minus the drain depth described below. The depth where an impermeable layer is said to exist is widely understood to be where the permeability of a soil is 10% or less of the soil layer above it. If this is not encountered at a depth shallower than 10 feet, it is assumed to exist at 10 feet because of the weight of the soil column in the top 10 feet, the lack of root channels and lack of earthworm activity, all of which reduce permeability.

Drain Depth below Groundline, feet: This is the depth from the average soil surface to the flow line of the tile or ditch, usually averaged for a single line or a drain system. If field logs show the depth to the top of the tile, the thickness of the tile wall and the inside diameter of the tile will be added to the depth to obtain the flowline depth. This is given in units of feet. The drainage system may be clay, concrete or plastic tubing or an open ditch. In an open ditch, this depth is measured to the typical free water surface, which may not be the ditch bottom.

Effective Radius of Tile: A tile's effective radius (re) is considerably smaller than the actual drain tube radius. This is due to the resistance to inflow due to a finite number of openings that allow water to enter the tile in an otherwise impervious wall. This parameter describes the proportion of the tile that actually allows water to enter the subsurface drainage system. In plastic drainage tubing, re is the approximate diameter of a tile which would be composed only of the holes cut into the plastic drainage tubing by which water enters the tile. For clay or concrete tile, this is an approximate diameter of a tile if it were somehow composed only of the cracks between the sections of tile where water enters the drainage system. A value of 12 inches is recommended for open drainage ditches. Compared to typical tile values (0.4-1.0 inch), this may seem large, yet it changes the lateral effect minimally.

The effective radius is to be determined from the table below which is derived from the DRAINMOD reference manual.

Time to Remove Saturation, T: For the situations described in Figures 1 and 2 in Exhibit 1, this is the 14 days as mandated in the NFSAM, third edition, which is effective at the time of this writing. For the situation in Figure 3 in Exhibit 1, the user is to read the time in days (whole days - no fractions) from the map provided in Exhibit 2. For the situation in Figure 3 in Exhibit 1, this is related to the water budget of the wetland and adjacent upland and the local rainfall and evaporation patterns. The plant water use affects this too. This is the time period, on a long-term average, over which sufficient rainfall falls at a given geographic location to "recharge" the soil column above the tile, such that the tile must then

Table 2. Effective Radius of Drainage Tile

Tile Diameter	Effective Radius, re, inches	Effective Radius, re, feet
4 inches	0.20	0.0167
5 inches	0.41	0.034
6 inches	0.58	0.048
8 inches	0.96	0.080 (extrapolated)
10 inches	1.33	0.111 (extrapolated)
12 inches and larger	1.70	0.142 (extrapolated & limit set)
Ditch, any size	12	1.0 (chosen by experience)
Drain tube	1.177n*	1.177n*

*surrounded by a gravel envelope with a square cross-section of length 2n on each side remove the free water from the soil immediately above it again.

Surface Roughness: This parameter describes the small amount of moisture that may be held on the surface of the soil by the particles (not any depressional topography) and will need to move through the soil column rather than running off or being evaporated or used by a plant. This must be small, since the drainage equations are not set up to handle ponded water (except Kirkham's equation). A value of 0.1 inch is used in Minnesota. This is consistent with a description on page 2-11 of the DRAINMOD reference manual for a surface that has been smoothed by weathering (wind and water here in the Midwest). The user does not need to enter this value. It is built into the program.

References:
Natural Resources Conservation Service, Fort Worth, TX, Student Notebook for NEDC class, "Hydrology Tools for Wetland Determination"

Jacobsen, Sonia M. M. and R. Wayne Skaggs, "Lateral Effect: What's Known and Unknown", American Society of Agricultural Engineers (ASAE) paper 972034, 1997, 9 pages.

(c) Multiple soils

See Exhibit 3 for an example of how to calculate the lateral effect where more than one soil is involved.

(d) Practical Limits

When preparing tables of lateral effect values for counties in Minnesota, the maximum lateral effect to be specified is 250 feet. Soils with a sandy substratum often have long calculated values that may or may not be realistic in the field.

For the sake of uniformity, any tables of lateral effect values for tile in Minnesota counties will use an effective radius of 0.048 ft, which is the value for a 6 inch tile. A change in the effective radius has a minimal affect on the computed lateral effect distance.

A drainage ditch or tile must have at least 12 inches of effective depth before it is considered to have any lateral effect (affect on subsurface flow). The ditch or tile may affect surface water movement with a depth of less than 12 inches.

Soils data in NASIS is specific to each county. If a soil is missing, consult the area soil scientist and area engineer for a recommendation.

650.1906 NRCS drainage guides

The Minnesota Drainage Guide does not contain information specifically on the impact of drainage on wetlands. It was developed for optimal drainage of cropland. The basic information on how drainage works applies to both situations.

650.1907 Observation wells

Little data exists for observation wells in Minnesota. The "Reference Wetland Simulation" procedure developed by Dr. R. Wayne Skaggs has been used with a short observation well record. Contact the State Conservation Engineer for information. Information is available on how to install monitoring wells also.

Exhibit 1. Possible Situations in Which to Determine Lateral Effect

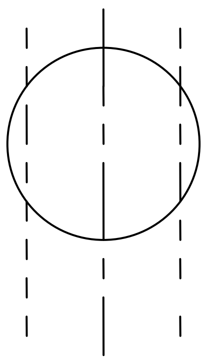


Figure 1. Single tile line or ditch passes through wetland and is unlikely to affect the hydrology of the entire basin in a normal 14 days.

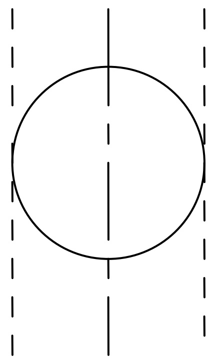


Figure 2. Single tile or ditch passes through wetland where it may affect the hydrology of the entire site within 14 days.

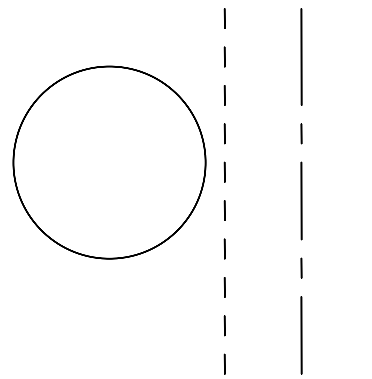
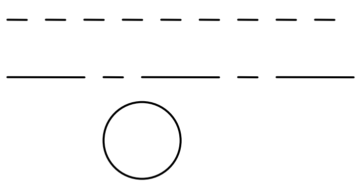


Figure 3. Tile or ditch will be installed adjacent to the wetland but want to avoid impacting the hydrology of the wetland within the time from Exhibit 2.

Legend:



Extent of lateral effect of drain

Centerline of drain (tile or ditch)

Wetland Boundary

Exhibit 2. Map for Determining Time Factor to use in van Schilfgaarde Equation

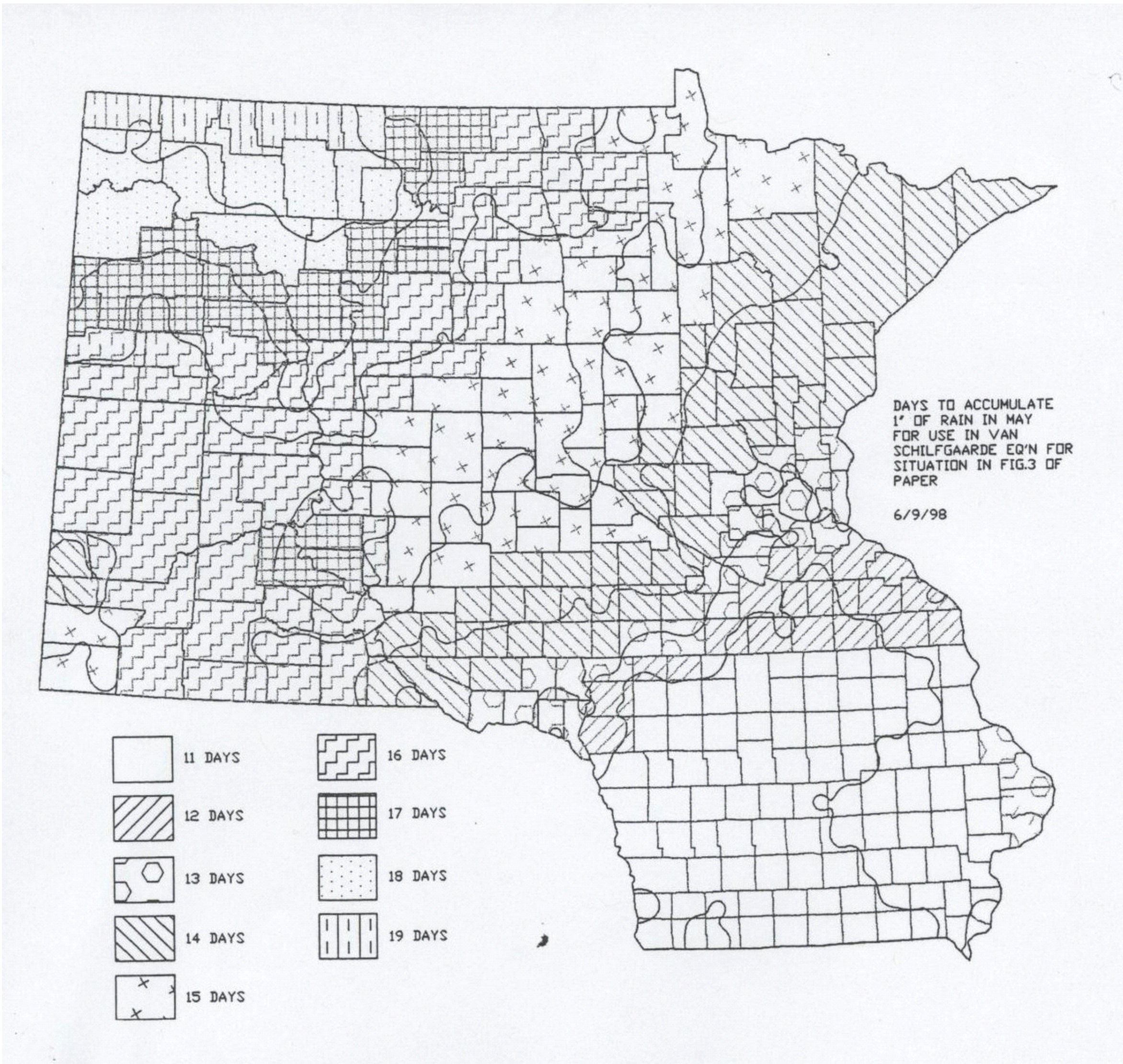


Exhibit 3. Example Problem for Calculating Lateral Effect in Multiple Soils

Question: A wetland in Mower County lies in Clyde soil but the last 50 feet of Clyde soil do not meet the wetland vegetation criteria. The adjoining soil is Floyd, where 6" plastic drainage tubing will be installed 4' deep. What is the lateral effect distance to stay away from the wetland boundary?

Answer: For Mower County, t = 12 days from Figure 1. Using the DRAIN-NASIS computer program, the lateral effect for a 6" drainage tubing installed 4' deep is calculated for both Clyde and Floyd soils using the Skaggs equation.

Le = 110 feet in Clyde soil (use without rounding)
Le = 138 feet in Floyd soil (round to 140 feet)

If the two lateral effect distances are within 10% of each other, an average can be used without further computations. However, if the soils' lateral effect distances differ by more than 10%, as these do, the lateral effect is determined by pro-rating the "drawing power" of the tile.

$$\frac{\text{Distance in soil}}{\text{Lateral Effect}} = \frac{\text{50 feet}}{\text{110 feet}}$$ = 45% of the "drawing power" of the tile is used in the Clyde soil

100% - 45% = 55% of the "drawing power" of the tile is to be in the Floyd soil

$$0.55 = \frac{\text{Distance in soil}}{\text{Lateral Effect}} = \frac{x}{\text{140 feet}}$$ Therefore, x = 77 feet, but round this to 80 feet

Therefore, the drainage tile needs to be a total of 130 feet from the wetland boundary (50 feet in the Clyde soil plus 80 feet in the Floyd soil).